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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 250.

THE PREVENTION OF STINKING SMUT OF WHEAT AND
LOOSE SMUT OF OATS.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 5, 1906.

SIR: I have the honor to transmit herewith a manuscript on "The Prevention of Stinking Smut of Wheat and Loose Smut of Oats," by Mr. Walter T. Swingle, physiologist in charge of investigations of plant life history, and to recommend the same for publication as a Farmers' Bulletin. This bulletin, prepared in advance of a more extended publication on the same subject, is intended to be of use in treating wheat during the coming season, and is primarily for distribution among farmers in the Northwest. A Farmers' Bulletin covering all smuts of cereals is now in preparation.

Respectfully,

ALBERT F. WOODS,
Acting Chief.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
The importance of treating seed wheat in order to prevent smut.....	3
Other smuts which cause damage to cereal smuts.....	4
Principal treatments for wheat smut.....	4
Sar treatment.....	5
Detailed directions for making and applying sar solution.....	5
Treating the grain with sar solution.....	7
Bluestone and lime treatment for stinking smut of wheat.....	8
Detailed directions for applying bluestone and lime treatment.....	8
Formalin treatment for stinking smut of wheat.....	8
Detailed directions for applying the formalin treatment.....	9
Hot-water treatment for stinking smut of wheat.....	9
Detailed directions for hot-water treatment.....	10
Handling the seed after treatment.....	12
Drying grain after treatment.....	12
Disinfection of the drill.....	13
Treatment for loose smut of oats.....	13
Treating a small field of grain for seed.....	15
Summary.....	15

ILLUSTRATIONS.

	Page.
FIG. 1. Head of beardless wheat affected with smut.....	3
2. Head of bearded wheat affected with smut.....	3
3. Outfit and materials for preparing the sar solution.....	6
4. Diagram showing arrangement for treating smutted seed.....	11
5. Head of oats affected with smut, the chaff being only partially destroyed.....	14
6. Head of oats decidedly smutty, but having the chaff only partially destroyed.....	14
7. Final stage of oat smut, showing condition at harvest time.....	14

THE PREVENTION OF STINKING SMUT OF WHEAT AND LOOSE SMUT OF OATS.

THE IMPORTANCE OF TREATING SEED WHEAT IN ORDER TO PREVENT SMUT.

The grain smuts cause an enormous loss to the farmers of this country and one which could be entirely prevented with but a very slight outlay and with a minimum of trouble. Until a few years ago many grain smuts could not be treated with any certainty of success, but now practically all can be prevented absolutely by



FIG. 1.—Head of beardless wheat
affected with smut.



FIG. 2.—Head of bearded wheat
affected with smut.

methods of seed treatment which cost but little. The stinking smut^a of wheat causes the kernel to swell up slightly and become filled with a powdery mass of black smut spores having a very disagreeable odor. The whole head, if smutted, contains no sound grain, only smutted kernels. (See figs. 1 and 2.) Such smutty wheat goes

^a Sometimes known as bunt.

through the thrashing machine with the sound grain, and it is difficult to separate it from the sound wheat unless the grain be washed, although a powerful fanning mill will take out part of it. These smutty kernels, the so-called "smut balls," contain the infecting material and a few of them are able to contaminate a mass of sound seed grain.

This dangerous parasite is widely spread throughout the wheat region of the United States, and is, unfortunately, easily carried from one farm to another by thrashing machines. Wheat containing any appreciable percentage of stinking smut has a disagreeable odor, and is frequently subjected to a heavy discount by millers on this account. It is perfectly feasible for every farmer to protect himself not only from this discount, but also to get materially increased yields in case his wheat is badly infected with smut. There are few parasites so easily combated as this, and there is really no excuse for an up-to-date farmer having smutty wheat, since it can be absolutely prevented with little or no expense, and the labor of making the treatment is insignificant compared with the benefits resulting.

OTHER SMUTS WHICH CAUSE DAMAGE TO CEREAL CROPS.

The greatest loss from smuts in this country is from the stinking smut of wheat, just described, and the loose smut of oats (see figs. 5, 6, and 7, p. 14), in which crops the loss probably averages from \$10,000,000 to \$20,000,000 a year each. The loose smut of wheat occasionally causes considerable injury, and is a very serious disease, because it is extremely difficult to prevent, even by seed treatment. Loose smut of oats, on the contrary, is very easily prevented, as are the stinking smuts of wheat. There are two types of barley smuts, both loose smuts, but the one easy to prevent, like oat smut, and the other rather difficult to treat, like the loose smut of wheat. The present publication will take up primarily the stinking smut of wheat, and will mention the loose smut of oats, while the methods of treatment for loose smut of wheat and for barley, rye, sorghum, and corn smut will be given in a bulletin now in preparation.

PRINCIPAL TREATMENTS FOR WHEAT SMUT.

Any of the treatments hereinafter given will prevent wheat smut, and by reading over the condensed account of the treatments and then the summing up of the advantages and disadvantages of each treatment on page 16 the farmer can decide which is best for him to use, and can then follow the detailed directions given in small print.

SAR TREATMENT.

Sar^a solution is made by mixing 15 pounds of flowers of sulphur with one-half pound of powdered resin, wetting with about 6½ quarts of water to a thick paste, then adding 10 pounds of dry powdered caustic soda (concentrated lye), stirring vigorously while the whole mass turns reddish brown and boils violently. Enough hot water is added to bring the solution up to 6 gallons. This stock solution is preserved in tightly corked jugs and must be shaken well before being used.

The seed wheat is treated with sar solution as follows: Either 1 quart of the solution is diluted with 50 gallons of water and the grain soaked therein for about twelve hours, or else a strong solution (1 gallon of the stock to 50 gallons of water) is used and the grain soaked only two hours. In either case the grain must be stirred several times during the treatment and spread out to dry afterwards. If the grain contains much smut, it should first be washed with water in order to skim off the smut balls before it is put in the sar solution to soak. This is true of all smut treatments.

Detailed Directions for Making and Applying Sar Solution.

Take one-half pound of ordinary resin and powder it finely until it makes a gray powder almost like flour. This can easily be done by pounding the resin in a sack with the broad side of an ax or by tamping in the bottom of a dry pail or kettle with a hard, rather heavy stick. Then mix this one-half pound of powdered resin thoroughly with 15 pounds of ordinary flowers of sulphur, and when the two are thoroughly mixed add, little by little, about 6 quarts of water, stirring all the time. At first the water added is not sufficient to moisten the whole mass and it crumbles when stirred, but when the right amount has been added the sulphur and resin make a stiff paste, which does not crumble when stirred nor flow when left alone. It is important that not too much water be added, since if the powder is thin and watery the sar solution is of inferior quality. This paste should be made in the bottom of a barrel or large keg *holding at least six times the bulk occupied by the paste, and preferably more.* Before this barrel is used 6 gallons of water should be measured out carefully and poured into the barrel as it sits in a level place. Then three or four wire nails should be driven in exactly at the level of the water, so that it is easy to see when the barrel is filled up to this point. The nails should be driven in from the inside, and the heads should project only a small amount, so that they will not interfere with the stirring of the contents. Instead of nails, wooden pegs may be driven tightly into small gimlet holes. (See fig. 3.) Then pour out 10 pounds of granulated caustic soda, which can be obtained everywhere under the name of con-

^a The word sar was adopted as a short name for this fungicide, being coined from the first letter in each of the words sulphur, alkali, and resin.

centrated 98 per cent lye or caustic potash.^a Then throw the 10 pounds of caustic soda on top of the sulphur-resin paste and stir rapidly and thoroughly. In a few minutes the paste begins to turn a reddish brown and slowly liquefies. It can be stirred to best advantage at this stage, and should be thoroughly agitated with a flat paddle. In a few seconds more the whole mass turns into a deep brown liquid and boils violently, running over the sides of the containing vessel, unless it is of ample size. It should be stirred all the time, and after a minute or so it will cease boiling, and the reaction is complete. Hot water should then be added slowly, all the while stirring until the solution is brought up to the 6-gallon mark. About 2 gallons of water will be needed. If hot water can not be obtained, cold water will do, but it must be added very slowly in order to prevent its spoiling the mixture.

This constitutes the stock sar solution, and it should be allowed to stand a few minutes, until any dirt or uncombined sulphur has settled to the bottom,

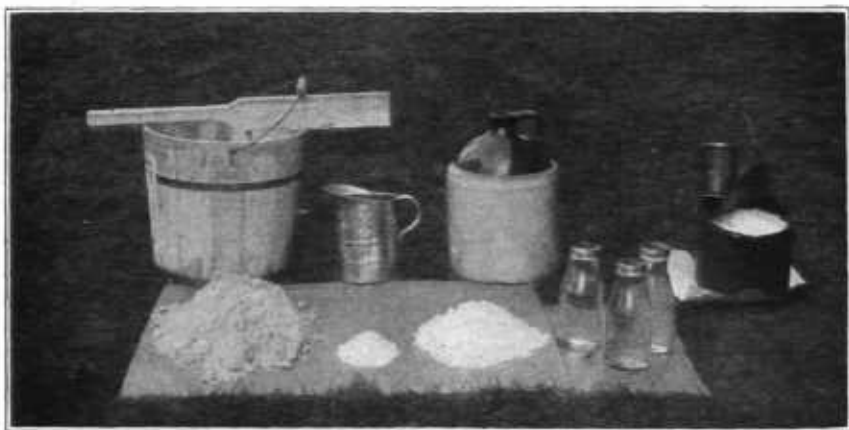


FIG. 3.—Outfit and materials for preparing the sar solution: To the left, in front, are $3\frac{3}{4}$ pounds of flowers of sulphur, then 2 ounces of powdered resin, then $2\frac{1}{2}$ pounds of caustic soda, and on the right 3 pints of water. Behind, to left, a candy pail, with peg on right marking $1\frac{1}{2}$ gallons, and paddle on top for stirring; in middle, a 2-quart graduate, marked with pints, for measuring water, and to the right the jug to hold the stock solution. To the extreme right are a 10-pound drum and a 12-ounce can of granulated caustic soda (98 per cent concentrated lye).

and then dipped off and poured into jugs. The scum that floats on top should not be thrown away, as it is a kind of resin soap and makes the mixture wet

^a Caustic soda of 98 per cent purity can be procured on the market in 10-pound sheet-iron drums, as shown in fig. 3 to the right, costing from 5 cents to 10 cents per pound wholesale. Such caustic soda is usually not finely powdered, but granulated, and should be sifted through a grain sieve or through a piece of mosquito netting and the coarser parts pulverized before being used if only a small amount of sar solution is to be made up. Care should be taken not to breathe the powder while sifting, as the caustic soda acts powerfully on the skin and lungs. It can be sifted carefully into a deep pail where there is a slight breeze of wind blowing from the operator. If the full formula given above (15 pounds of sulphur and 10 pounds of caustic soda) or more is made up at one time, the granulated caustic soda can be used without sifting. It should be remembered that caustic soda takes up moisture from the air, and it must be kept tightly sealed in fruit jars or otherwise, if not used at once. If particles of caustic soda fall on the clothing, discoloration is likely to be caused.

the grain better. The jugs should be filled nearly full and then tightly corked. In this way the mixture can be preserved for months without the least deterioration. If there is a large quantity of sulphur left at the bottom of the barrel after the solution has been poured out, it is a sign that the mixture has not been properly prepared; either the caustic acid was not full strength or the paste was too wet or not properly stirred during the reaction. Only a few ounces of sulphur will remain if the solution has been prepared properly. It should be particularly noted that concentrated lye is often sold in tins which contain not a pound, but only 12 to 13 ounces. It is much better to weigh out the caustic soda, or to weigh carefully one box and determine how many ounces it contains. Caustic soda can also be obtained in 10-pound tins from any wholesale grocer at a price of about 6 to 10 cents per pound, depending on the distance from the principal distributing centers. Flowers of sulphur can be bought in barrel lots at from $2\frac{1}{2}$ to 5 cents per pound, and resin in lumps ranges in price from 2 to 3 cents per pound for large quantities.

One-fourth of the above formula can be made in a candy pail as shown in figure 3. This gives $1\frac{1}{2}$ gallons of stock solution, or enough for 75 gallons of the solution ready for use, in which the grain is soaked for two hours.

Treating the Grain with Sar Solution.

The wheat should first be thrown into barrels, or, preferably, a large tank having a bunghole at the bottom protected on the inside with a bit of wire screen, so that the liquid can be drained off.^a Then fill the barrel or tank about two-thirds full of grain and fill the barrel to the top with cold water. Any smut balls which float should be skimmed off, and the grain should be stirred with a hoe or paddle to be sure that all the smut balls come to the top. These smut balls must be burned or buried, since they contain the spores of the smut fungus and are able to infect wheat again after it has been treated. Then the water is drained off and the wheat is ready for treatment. If the farmer does not have much seed to treat, it will be better to take one quart of stock sar solution ^b to 50 gallons of water. This should be stirred well in a barrel and then poured over the wheat until it is covered several inches deep. The wheat should be stirred thoroughly to be sure that all the kernels are wetted and should be left from ten to fifteen hours in the solution, either from early morning till the evening, or, better, from the evening until the early morning. It should be stirred several times during the treatment, and, if necessary, more solution added to keep the grain thoroughly wetted. The grain should then be removed and spread on a clean barn floor or on canvas spread on slats in order to dry and it should be raked over to facilitate evaporation. The seed can be sown as soon as it is fairly dried, or, if properly dried, so that it does not heat, can be kept a week or so before it is sown.

In case the farmer has a large amount of seed to treat, it will be better to use a much stronger solution and to treat the seed a shorter time. For this purpose 1 gallon of stock solution should be diluted to 50 gallons and the seed treated with frequent stirring for two hours. This solution can be used several

^a The best tank, about the size of a wagon box, is made of matched flooring, with tongues and grooves, white leaded, and with one end sloping gradually, so a scoop shovel can be used for removing the grain and a rake or hoe for stirring it during treatment.

^b The stock solution should be shaken well in the jug before being poured out so as to distribute the resin soap evenly throughout the solution before the amount needed is measured out.

times, but should not be employed the second day, as it loses its strength rapidly.

The weak solution first mentioned should not be used more than once, and can be drained off the grain and allowed to flow away.

BLUESTONE AND LIME TREATMENT FOR STINKING SMUT OF WHEAT.

Dissolve 2 pounds of crystallized (not powdered)^a commercial copper sulphate or bluestone in 50 gallons of water. Soak the grain about twelve hours in this solution, stirring occasionally, and then after draining a few minutes immerse in lime water made by slaking 2 pounds of good lime and then diluting with 20 gallons of water.

Detailed Directions for Applying Bluestone and Lime Treatment.

First, 1 pound of copper sulphate is dissolved in 24 gallons of water. This can be done most easily by tying the copper sulphate crystals in a piece of coarse gunny sack and suspending them near the top of the barrel. They will dissolve in a short time even in cold water. The wheat should be first washed in water as directed under sar treatment, if there is any considerable amount of stinking smut present. Then it is soaked in the bluestone solution for about twelve hours, and then dipped for five minutes in limewater, which is made by slaking 1 pound of good stone lime and then diluting to 10 gallons of water after it is slaked. The wheat should be stirred several times while in the bluestone solution and should be agitated thoroughly while being dipped in limewater. This treatment is the oldest of the thoroughly successful treatments against stinking smut, and at the same time one of the cheapest and most effective. Crystallized copper sulphate in 10-pound lots should cost from 8 to 10 cents per pound, so that 50 gallons of solution can be made at a cost of from 16 to 25 cents.

In many parts of the country the bluestone treatment is employed already, but the grain is not dipped in limewater afterwards. The omission of the treatment with limewater is likely to injure the germinating power of the seed, and should never be omitted. As a matter of fact, dipping in limewater causes a very thin layer of Bordeaux mixture to be formed around each grain of wheat, whereas the copper sulphate if present might injure the young seedling when the grain begins to germinate. The tank noted under the sar treatment can also be used to advantage with this treatment.

FORMALIN TREATMENT FOR STINKING SMUT OF WHEAT.

Dilute 1 pound of formalin,^b which must be a full strength 40 per cent solution of formaldehyde, with 50 gallons of water. Put the wheat to be treated in a pile on a barn floor, or other smooth, hard surface where a shovel can be used, and sprinkle the solution over the

^a Powdered commercial copper sulphate is often adulterated and is no easier to dissolve than the crystallized.

^b Formalin is a trade name for a 40 per cent solution of formaldehyde. When large quantities of seed grain are to be treated, the farmer would do well to get prices on formaldehyde solutions of guaranteed strength, since such solutions are often sold cheaper than is formalin.

grain with a sprinkling pot, using about 1 gallon to each bushel of grain. The grain must be shoveled over until thoroughly wet and left in the pile about two hours. It can then be spread out to dry.

Detailed Directions for Applying the Formalin Treatment.

Formalin is a trade name for a 40 per cent solution of formaldehyde, and it is important to be sure that the solution purchased is of full strength and that the bottles contain full weight of the solution. One pound of formalin should be dissolved in 50 gallons of water and then sprinkled over the seed of the wheat which is spread out on the barn floor or other smooth surface.

The wheat must be shoveled over until it is thoroughly wet with this solution, and it is best to use a sprinkling pot in applying it to the grain. The formalin gives off rather pungent fumes, and for this reason it is probably the most effective treatment for wheat smut that can be applied in this manner. Much less solution is required than when the grain is soaked, as in the treatments before mentioned. One gallon of solution will just about wet 1 bushel of grain, so that very much less solution is required than when the grain must be immersed. The grain should be left in a pile for two or three hours and then spread out thin so it can dry.

It is necessary to make sure that the formalin is really a 40 per cent solution of formaldehyde, as the solution rapidly loses strength if it is not kept tightly corked, and unscrupulous dealers sometimes dilute it with water. The bottles are also often underweight. It is necessary to insist on having a guaranteed 40 per cent solution, and the contents of a bottle should be weighed to make sure it is full weight. If the solution is too weak, the smut will not be entirely prevented, and there is risk of having gone to much labor for nothing. A pound bottle of formalin 40 per cent strong costs from 50 cents to \$1.

HOT-WATER TREATMENT FOR STINKING SMUT OF WHEAT.

Dip the wheat in hot water at a temperature of from 132° to 133° F. The seed should be placed for the purpose in a coarsely woven basket covered with wire netting, or else in a coarse gunny sack. The basket or sack must not be filled full, as the grain must be loose inside. There should be six or eight times as much hot water as the bulk of the grain to be treated, and the temperature of the water must be kept at the right point by letting in steam or by adding hot water from time to time, if necessary. The grain must be lifted out of the water four or five times during the treatment and allowed to drain. This is needful to insure that all the grain comes into intimate contact with hot water at the right temperature.

If not convenient to keep the water at 132° or 133°, it may be allowed to go higher, but the treatment must be shortened, and *at 145° F. the treatment must not be prolonged beyond five minutes*, and care must be taken that the water is even in temperature throughout; otherwise some grain will be killed and other grain insufficiently treated so the smut will not be killed.

If steam is available the water can easily be heated by conducting a steam pipe into the vessel. The steam, in getting in, heats the

water and at the same time stirs it thoroughly. The hot-water treatment requires no outlay at all for chemicals, but requires careful attention and considerably more labor than any of the other treatments mentioned before. If properly carried out it is undoubtedly the best treatment for all kinds of grain smuts.

Detailed Directions for Hot-Water Treatment.

The smut balls, if abundant, should be floated and skimmed off, as for all other treatments. Then provide two vessels to hold water, one full of warm water at a temperature of 110° to 120° F., in which the grain is dipped several times to take the chill off, and one large vessel of hot water preferably held at 132° to 133° F., but in no case to go below 130° or above 145° F. In this the grain is treated from five to fifteen minutes, depending on the temperature. If held closely to 132° or 133° F., ten minutes' treatment is sufficient; if at 130° F., it must be prolonged to fifteen minutes, and if the temperature is 145° F., only five minutes' treatment should be given. The volume of water must be from six to ten times that of the amount of grain to be treated at any one time.

Spread out in thin layer to dry at once, or, if this is not possible, dip in cold water to cool and put aside until the grain can be spread out to dry.

The water in the second vessel can be heated most easily with steam admitted by a pipe furnished with a stopcock. The steam heats the water rapidly and helps to stir it at the same time. Make the temperature uniform throughout the vessel.

Steam should *not* be admitted while the grain is being treated, as it might easily kill part of the seed.

The grain must be held in loosely woven gunny sacks, a covered basket lined with wire netting, or a perforated tin bucket, and in either case the sack or basket must not be more than two-thirds full. This is so that the water can enter and drain off quickly and the grain move about freely when the basket is agitated.

In treating wheat it is well to throw the grain into a vessel filled with cold water first, stir it well, and skim off the smutted grains that float on top, and then put the sound grain into the basket or other vessel containing the hot water. This placing in cold water and skimming is entirely unnecessary in treating other grain and even in treating wheat when it is affected by the loose smut only. Dip the basket of seed into the vessel containing the water at 110° to 120° F., after a moment lift it, and when most of the water has escaped plunge a second time into the same vessel, and so on several times. The object of the lifting and plunging, to which a rotary motion should be added, is to bring every grain in contact with the hot water. Less than a minute is required for this preparatory treatment. Now plunge the basket of seed into the vessel containing water at 132° to 133° F. Should the thermometer indicate that the temperature of the water is falling, add to it from the kettle of boiling water until the right heat is attained, or, should the temperature rise higher than 133° F., add a little cold water. Should the temperature rise as high as 145° F., the time of treatment should be reduced, as five minutes at this temperature suffices to kill the smut, and immersion for a longer time is likely to injure the seed. In all cases the water should be well stirred whenever either hot or cold water is added.

Very soon after its immersion in the second vessel containing the hot water the basket of seed should be lifted and drained, after which it should be plunged in again and agitated, as before described. This operation should be

repeated six or eight times and continued ten minutes. In this way every portion of the seed will be subjected to the action of the hot water. In practice it will be found best for one man (or boy) to devote his entire time to keeping the water at the proper temperature, letting in a little steam if the temperature falls below 132° F. and a little cold water if it rises above 133° F.^a The entire time of another man will be required in handling the grain to be treated.

After removing the grain from the hot water, spread on a clean floor or on a piece of canvas to dry. The layer of grain should not be more than 3 inches thick. If it can not be spread out at once, dip in cold water and set to one side until it can be attended to. It dries best if spread while hot. After one portion is spread out another can be treated, and so on, until all the seed has been disinfected. More detailed directions for drying seed will be found on page 13.

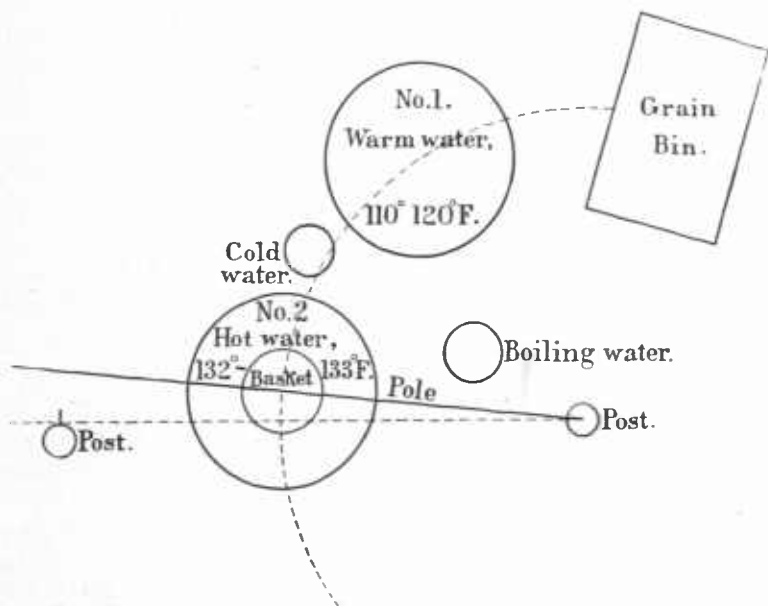


FIG. 4.—Diagram showing arrangement for treating smutted seed. If steam is used for heating the water, the two small vessels marked "boiling water" and "cold water" are not needed.

A good arrangement for hot-water treatment is shown in figure 4. A pole or beam having a hole at one end is passed over a peg in the top of the first post. The hole should be large enough to allow the pole to be moved up and down sidewise. By swinging the pole around, the basket can be filled at the bin, then immersed a moment in vessel No. 1, and then swung over to vessel No. 2, where the grain is treated ten minutes. Every minute or so the basket must be raised entirely out of the water and allowed to drain. The pole can be supported on a peg or fork in the second post while the basket is draining. Finally the pole is lifted entirely over the second post and the grain removed and spread out to dry. Of course this arrangement of posts and pole is unnecessary except where large amounts of seed are to be treated.

^a A good thermometer should be used, preferably one in which the bulb is protected against injury from striking the sides of the vessel. The large thermometer used in dairy work is a very good one for this purpose.

Where steam is not available the water may be heated by adding small amounts of boiling water from time to time or a little cold water if the temperature goes too high.

The important points to be remembered in the hot-water treatment are as follows: (1) Maintain the proper temperature of the water (132° to 133° F.), in no case allowing it to rise higher than 145° or fall below 130° F.; (2) regulate the time of treatment by the temperature, making it ten minutes in water at 132° to 133° F., fifteen minutes at 130° F., and five minutes at 145° F.; (3) see that the volume of hot water is at least six or eight times greater than that of the seed treated at any one time; (4) never completely fill the basket or sack used for treating the seed, but always leave room for the grain to move about freely; (5) never leave the basket or sack in the hot water all the time, but take out to drain a few seconds and plunge in again at least four or five times during the treatment.

HANDLING THE SEED AFTER TREATMENT.

All seed wheat treated for stinking smut must be dried out somewhat after treatment unless it is sowed broadcast. It can be drilled as soon as the grain falls apart readily, even though it still contains a good deal of water. The seed wheat will absorb about 10 per cent of moisture, so that, if drilled when still moist, about 65 pounds should be counted to the bushel. If carefully dried the seed wheat can be kept for some time before it is planted, but if put away in sacks or left in the pile while still moist, the seed is liable to heat and spoil. It is important to keep treated seed in smut-free sacks or bins. Sacks can easily be disinfected by dipping them in boiling water, and bins or barn floors can be disinfected by mopping them off with boiling water for several minutes to be sure that the adhering spores are wetted with boiling water.

DRYING GRAIN AFTER TREATMENT.

All of the treatments mentioned in this publication necessitate wetting the seed grain. The bluestone and lime treatment and the sar-solution treatment, in which the grain is soaked for twelve hours, cause it to absorb considerable moisture and necessitates drying somewhat before the seed can be sown. The same is true of the hot-water treatment. The treatment with sar solution for two hours and the sprinkling treatment with formalin do not cause the grain to swell as much, but it must still be dried somewhat before it can be drilled, although it can be broadcasted almost immediately.

In order to dry the grain it should be spread out on a clean floor or on a piece of canvas, and should not be more than 3 or 4 inches deep in order to dry rapidly, although if it can be shoveled from time to time it can be spread out in a thicker layer. One of the best drying outfits consists of a framework about 12 feet square made of 2 by 4 inch rafters set 3 feet apart and then lathed over, leaving about 1½

inches between the laths. This platform should be supported 1 or 2 feet above the ground so the air can circulate freely underneath. Then the grain can be spread out on canvas over this platform, and will then dry very rapidly. In all cases the drying floor or the canvas should be disinfected with boiling water before the grain is spread out, and when the grain is put in sacks for drying, the sacks must also be disinfected by dipping in boiling water.

DISINFECTION OF THE DRILL.

The drill should be disinfected before seed wheat is sown. This can usually be done by blowing and brushing it out thoroughly and then running some air-slaked lime through the drill. If there is no danger of the parts rusting, boiling water or a solution of formalin can be run through the drill and accomplish the same result more quickly.

TREATMENT FOR LOOSE SMUT OF OATS.

The loose smut of oats (see figs. 5, 6, and 7), unlike stinking smut of wheat, is not easily carried from farm to farm by the thrashing machine, and treated seed is not easily reinfected from sacks or the drill. This renders it easy for the farmer to eradicate this disease and keep his oat fields free from it. Loose smuts are spread largely by the wind at flowering time, and by the time the grain is ripe almost all trace of the disease has disappeared and its presence is not revealed by the odor of the thrashed grain. This often leads farmers to underestimate greatly the amount of damage from oat smut, which frequently destroys from 10 to 20 per cent of the heads and injures other heads it does not destroy. Wherever any noticeable sprinkling of black smutted heads is to be seen at flowering time loose smut is causing a decided loss to the farmer and the seed should be treated. Oat smut is still more widely spread than wheat smut, and occurs all over the United States.

The most extensive series of counts to show the percentage of oat smut was made in the oat fields of Illinois by the agricultural experiment station, and the average of the counts made in all parts of the State is 6 per cent. The same bulletin, No. 57, in which these counts were published says:

The average yearly value of the oat crop in this State [Illinois] for 1895 to 1898, as taken from the reports of the United States Department of Agriculture, was about \$15,500,000. If 6 per cent represents the average loss, it would mean that this fungus cost the farmers of this State during that time about \$1,000,000 a year.

Loose smut of oats can be treated the same as wheat smut, with the exception that the copper-sulphate treatment can not be used with

success, since oats are very sensitive to copper. The sar and hot-water treatments are especially effective for oats, which are also treated successfully by sprinkling with formalin, as directed for stinking smut of wheat. The hot-water treatment is particularly good for oat smut, and if properly carried out will destroy the smut



FIG. 5.—Head of oats affected with smut, the chaff being only partially destroyed.



FIG. 6.—Head of oats decidedly smutty, but having the chaff only partially destroyed.



FIG. 7.—Final stage of oat smut, showing condition at harvest time.

absolutely, so that not one smutty head can be found in a large field. It must not be supposed that seed oats do not need treatment merely because, unlike wheat infected by stinking smut, the grain does not have a bad odor. Often a large percentage of the oats is destroyed by this smut, and it is the uniform experience of all experimenters

who have used either hot water or the sar solution that the increase in yield from treated seed is more than would result from merely replacing smutted heads with sound ones. This probably is partly because of the better germination of oat seed that has been soaked, but is also in part doubtless due to injury of oat heads by the smut fungus, though the heads do not show any smut. It is not an uncommon thing for oats to be 10 per cent smutted, and such oat seed, if treated, often yields all the way from 12 to 20 per cent more grain than untreated seed.

TREATING A SMALL FIELD OF GRAIN FOR SEED.

In case the farmer feels that he can not undertake the treatment of all his seed grain, he should at any event treat the seed carefully for a field large enough to furnish his supply of seed wheat for the following year. Since the land to be treated in this case is very much cut down, he should use the greatest care and make the treatment a thoroughly effective one. For such treatments hot water is without doubt the best for oats, while sar solution, hot water, and blue-stone and lime treatments are about equally effective in preventing stinking smut of wheat, and the farmer can choose the treatment which is easiest for him to apply. If there is the slightest suspicion that smut is present in the grain, some method should be taken to insure having grain reasonably free from smut. Such a seed field should be located somewhat removed from the other fields, and in the case of stinking smut of wheat there is always the danger that the seed may be infected during thrashing. Oat smut may blow considerable distances from one field to another, and the farmer can plant such fields in a well isolated place. It will nevertheless be more certain if he treats all his seed grain and in this way prevents all damage from smut, which often amounts to as much as 5 to 20 per cent.

SUMMARY.

Stinking smut of wheat not only destroys a proportion of the wheat, sometimes as high as one-tenth to one-fifth or even more, but also renders less salable the sound wheat because of the disagreeable odor which this smut imparts to anything which it touches. In preventing wheat smut by soaking the seed before planting, the farmer will therefore avoid a double loss—the injury caused by the smut and the discount which his wheat suffers at the hands of the dealers.

Any of the four treatments recommended in this bulletin can be carried out at a very small expense by any farmer with the aid of utensils to be found on any farm. The relative advantages and disadvantages of these treatments are shown in the following summary.

Sar solution.—The easiest treatment, in which the grain is soaked. The solution is easily prepared, cheap, can be kept any length of time, and if properly applied is thoroughly effective.

Bluestone and lime treatment.—This treatment is even cheaper than the sar solution, but it requires that the grain be dipped in lime water after it has been soaked in the bluestone solution. While the farmer is already familiar with the bluestone treatment, it should be improved, as here suggested, by dipping the seed in limewater. It is a thoroughly effective treatment for wheat smut, but is dangerous for oats.

Formalin solution.—The formalin solution is, as far as is now known, the best treatment for grain in bulk by sprinkling. This is by all odds the easiest treatment to apply on a large scale, but the smut is not so thoroughly prevented as when the grain is soaked or treated with hot water. The principal drawback to this treatment is the difficulty of getting formalin of guaranteed strength and the fact that the bottles are often short in weight. On account of the expense of the solution it should not be used for soaking the grain, but only used where the grain is treated in bulk by sprinkling.

Hot-water treatment.—The hot-water treatment requires no outlay for material, but necessitates a considerable amount of labor and must be carefully done or the seed wheat will be injured. If carried out properly, however, it is the most effective treatment known for all smuts. It can be recommended in practice even where large quantities of wheat are to be treated wherever steam is available for quickly heating the water.

Value of treatment for seed wheat and oats.—There is no longer any excuse for an up-to-date farmer having smut in his wheat or oat fields. It is now possible to prevent these diseases so cheaply and so easily that every farmer should treat his seed grain if there is the slightest indication that it is infected with smut. The expense is small and the result sure. He will harvest more wheat and better wheat, and have the satisfaction of knowing that he is getting the full return from the crop and that his grain is not subject to any discount on account of smut.